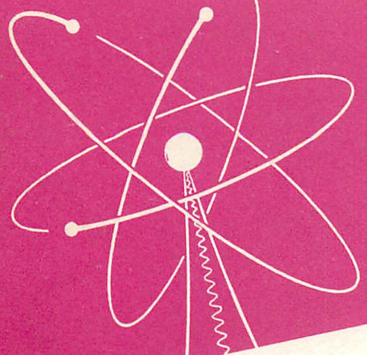
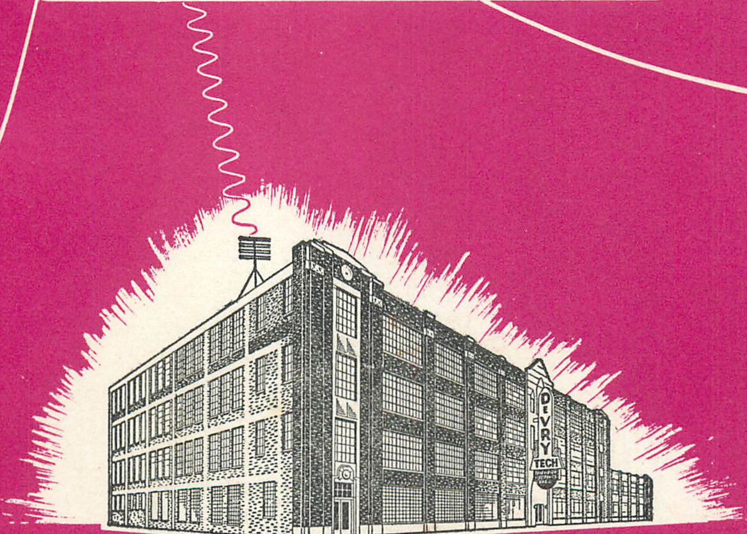


RECEPTION PROBLEMS

Lesson T4E-18B



E-18

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4141 W. Belmont Ave., Chicago 41, Illinois
Formerly DeFOREST'S TRAINING, INC.

T4E-18B

RECEPTION PROBLEMS

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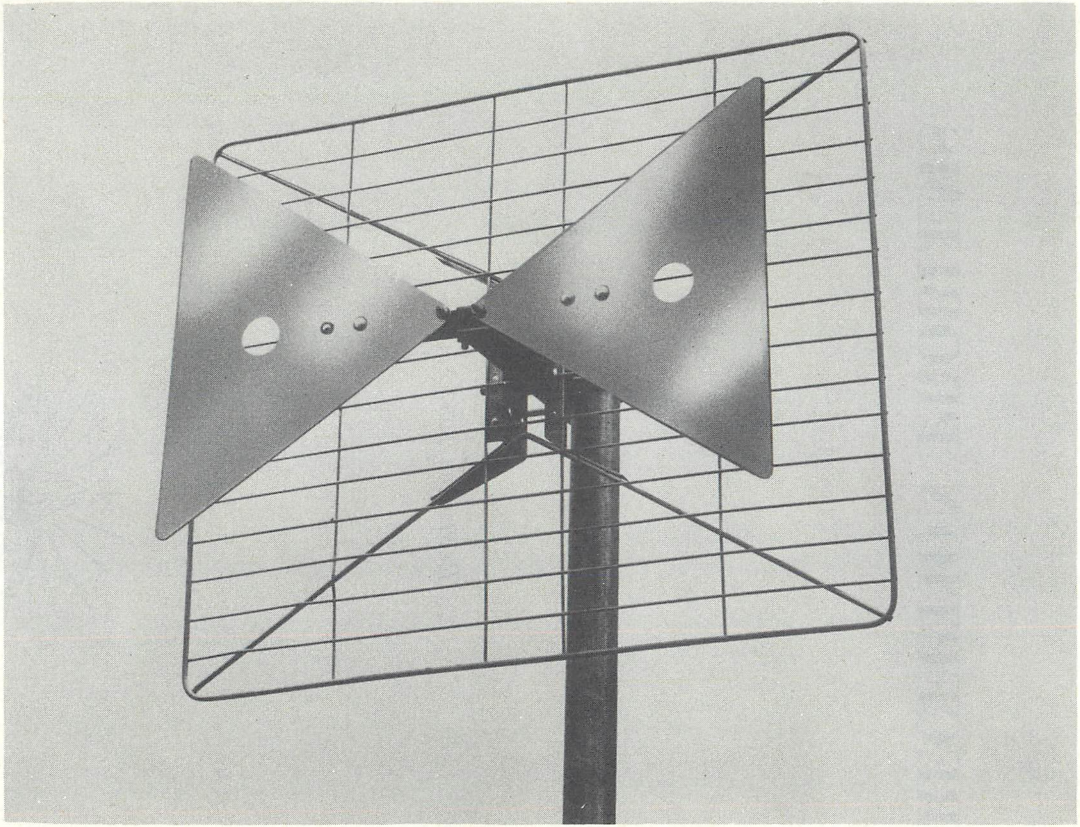

A "bow-tie" antenna with a sheet reflector is suitable for all UHF channels. The holes in the bow-tie reduce wind resistance.

Courtesy Channel Master Corporation

RECEPTION PROBLEMS

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National networks for television programs are already in use. Networks to South and Central America and to other countries are scientifically, if not economically practicable today. Thus television might well bring about international languages and international thinking. During the war countries developed a tremendous capacity for international cooperation. Television's role in our civilization may prove to be a peacetime guard against war's imminence.

—Selected

RECEPTION PROBLEMS

In a previous lesson, the mechanics of the normal antenna installation were described and, at the same time, it was pointed out that a large variety of antennas are available for the various reception conditions.

Since an almost unlimited number of reception problems exist it is impractical, if not impossible, to list each one separately and prescribe a rigid procedure to follow.

Instead, in this lesson, various types of antennas are described along with proper applications of them to common, typical reception conditions. It then should be possible to go out, survey the reception conditions involved, and intelligently select and install a satisfactory antenna system.

DIRECTIVITY PROBLEMS

During the pre-installation survey, the approximate directions of arrival of the signals from the various stations serving the area should be determined, as well as the directions of undesired signals, such as a station occupying the same channel as a desired local station. Later probing operations not only will determine these directions more accurately, but also will determine the directions from which reflections or other interferences are received. However, with the survey information on hand, it is possible to decide what general directional characteristics are needed by the selected antenna system.

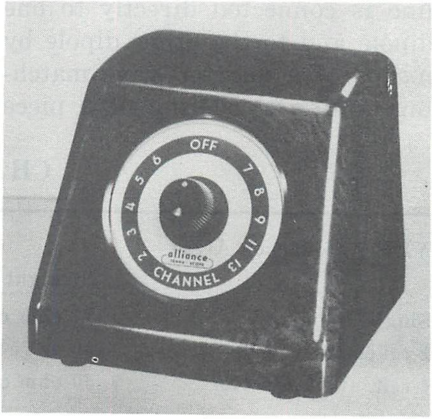
Four typical receiving situations are illustrated in Figure 1. In each case the block containing the letter "R" represents the receiver location, and the circles containing the letter "T" show the respective locations of the desired television transmitters.

In Figure 1A, the transmitters are all in the same general direction with respect to the receiver, and best reception may be expected with some type of unidirectional antenna such as a straight or folded dipole with one or more parasitic elements as shown in Figure 2. When no ghost or other interfering signals are present, and the signal strength is sufficiently high, a dipole or folded dipole without reflectors or directors can be used. However, a system which has additional elements similar to those illustrated generally is preferred, since it provides a voltage gain of from 1.5 to 2 times that obtained with the straight dipole.

To obtain reception from sources 180° apart, as pictured in Figure 1B, the bi-directional characteristics of a straight dipole or folded dipole without parasitic elements can be used. In this case, an arrangement like those of Figure 2 are not desirable, as the parasitic elements prevent sufficient signal pickup from one of the two stations. If needed, some increase in pickup from both directions may be obtained by employing two or more such dipoles in a stacked array, and either straight or folded dipoles can be used in this manner.

A receiver location such that the desired signals arrive from four directions is illustrated in Figure 1C. Providing reflections and noise signals are not troublesome, the simplest solution is an omni or all direction antenna, two types of which are illustrated in Figure 3. Known as **turnstile antennas**, these antennas have circular radiation patterns at the resonant frequency, but approach that of a dipole for signal frequencies above and below resonance. These units provide less pickup than a straight dipole, and should be used singly only in areas of relatively high signal strength. For greater pickup, either of the turnstile types may be used in a stacked array.

Figure 1D represents the situation where two desired signals arrive from sources approximately 90° apart, and either the signal strengths are not high, interference is present, or both. In this case, none of the antenna arrangements so far described are satisfactory. Therefore, acceptable performance requires the use of two separate antennas oriented for maximum pickup from each station using the arrangement pictured in Figure 4. Parasitic elements are used to increase signal pickup and reduce interference and ghosts. The antennas are mounted on the same mast, and spaced as far apart as possible, as shown.



A booster often is used to improve fringe area TV reception. In this unit, one control provides continuous tuning for all VHF channels.
Courtesy Alliance Manufacturing Co.

Where more than two widely separated stations are involved, as in Figure 1C, and the signal strengths are not high, it may be necessary to use antennas for each, mounted on a single mast in the same general manner as illustrated in Figure 4.

Always use a transmission line whose impedance is approximately equal to that of the antenna. The impedance of an antenna array varies with the number of elements, their arrangement, and the spacing employed. Chart 1 lists the impedances for the antenna systems mentioned.

In Figure 3A, the transmission line is connected directly to one dipole and to the other dipole by means of a quarter-wave matching section consisting of a piece of 75 ohm coaxial cable which is equal to approximately 0.9 the length of one rod of the antenna. A similar arrangement is used with the unit of Figure 3B, in which case the matching section is made from 300 ohm twin-lead.

CHART 1

VHF Antenna or Array	**Type of Transmission Line**	
	Straight Dipole	**Folded Dipole**
Single Element	**75 ohm coax cable**	**300 ohm twin-lead**
1 reflector	**50 or 75 ohm coax**	**300 ohm twin-lead**
1 refl. and 1 director	**50 ohm coax**	**75 ohm coax or 95 ohm twin-coax**
2 elements, stacked	**50 ohm coax**	**150 ohm twin-lead**
2 elements and refl., stacked	**50 ohm coax**	**95 ohm twin-coax or 150 ohm twin-lead**
Turnstile	**50 ohm coax**	**150 ohm twin-lead**
Separate antennas	**Individual lines; which depend upon the type of antennas used.**	

Where several individual antennas are used, the different transmission lines may run to the receiver by the same route. At the receiver, these lines are connected to the input terminals of an antenna-selector switch box on the panel of which the appropriate call letters or channel numbers indicate the respective stations.

SINGLE CHANNEL RECEPTION

Up to this point, the explanations have assumed a commercial type antenna which has been designed to resonate somewhere near the center of either the high or the low VHF television band or the UHF band so as to receive any station in the band. An antenna of this type, or a system capable of receiving in both VHF bands and the UHF band, is necessary in areas served by several stations. On the other hand, only one station can be received in many regions, in which case it is often advantageous or even absolutely necessary that the system be designed to give maximum performance on a single channel.

Tuning the antenna to the center frequency of the channel occupied by the desired station will increase the signal input to the receiver and also improve the signal-to-noise ratio. The element lengths required for the various VHF channels of a multi-element array are shown in Figure 5. As indicated by the small sketches at the left of the Figure, column A lists the lengths of the dipole, column R lists the reflector length, and column D lists the length of director number 1. When additional directors are employed as described later in this lesson, they are placed in line in front of the antenna as pictured in the lower sketches of Figure 5 and are numbered D_2, D_3, and so on. Columns D_2 & D_3 list the lengths of these added directors.

In a three element antenna, the reflector and director are spaced the same distance from the dipole as shown in column S. When two or more directors and a reflector are employed, the lengths listed in the S_R and S_D columns are the element spacing as indicated in the lower sketches at the left of Figure 5. The spacing values are calculated for a quarter wavelength between elements, but spacings greater or less than those given often may be found by experiment to result in more gain; that is, better pictures at a given setting of the contrast control.

Final tuning is accomplished by adjusting the distance or spacing between the inner ends of the dipole element, the point at which the transmission line is connected, for maximum picture brightness. These methods of increasing signal pickup may also be used for each unit where several separate antennas are employed as explained for Figure 4.

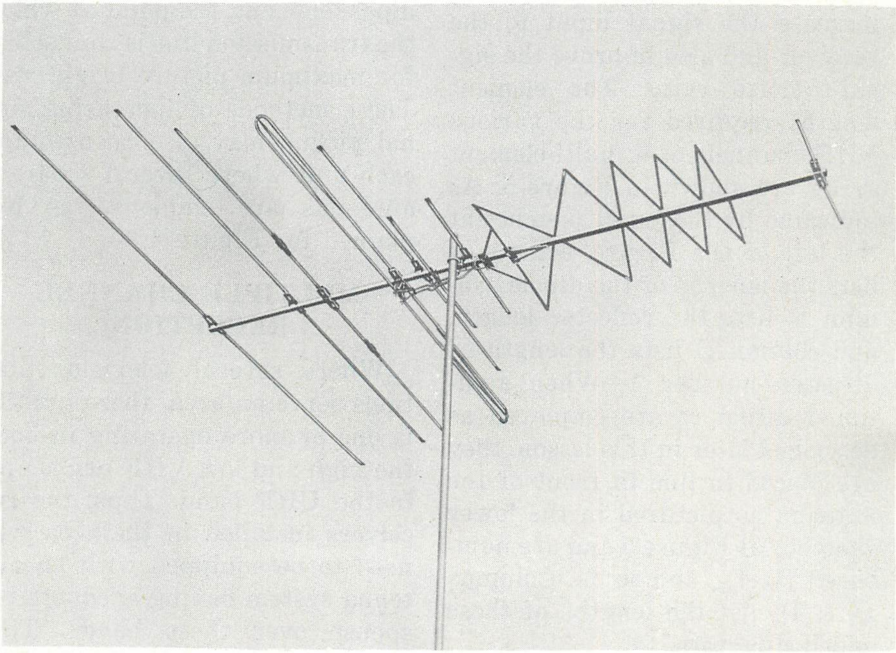
MULTIPLE CHANNEL RECEPTION

Where several television stations serve an area, there usually is one or more operating in both the high and low VHF bands and in the UHF band. Thus, the receivers installed in the area will need to be equipped with an antenna system having adequate response over these bands. This may be done by using two antennas, one which is broadly resonant over a range from 54 to 216 mc and the other resonant over a range from 470 to 890 mc. Or a three unit system may be used consisting of two antennas for the high and low VHF bands and one for the UHF bands.

Wide-Band Antennas

The response of a straight dipole is broadened to some extent by employing an intentional mismatch with the transmission line, such as by using a 300 ohm twin-lead. However, this arrangement has the disadvantages of less energy transfer to the line and the possibility of ghost images due to reflections on the line.

tive diameter, and lower Q than a straight dipole. Because of its lower Q, the folded dipole has a broader frequency response, as shown by the curves of Figure 6. Curve D represents the response of a straight dipole and curve F the response of a folded dipole with reference to the percent of the frequency deviation.



In weak signal areas, high gain antennas are required. This antenna covers the VHF Channels with uniformly flat gain, high signal-to-noise ratio, and close 300 ohm impedance match essential for fidelity color reception.

Courtesy JFD Manufacturing Co., Inc.

In the case of any dipole antenna, the Q is inversely proportional to the diameter, or the "effective diameter" of the rods or wires. A folded dipole forms the equivalent of a flat sheet of metal one-half wavelength long, and therefore has greater effec-

The bandwidth of the dipole can be increased still further by the use of rods having the form of large cylinders or of cones as illustrated in Figures 7A and 7B, respectively. Due to their large surfaces, both of these are rather impractical because of the likelihood of damage by wind. This danger is greatly reduced with the antenna construction shown in Figure 7C. Here, each cone consists of twelve wires attached at evenly spaced points on a ring at the outer ends, and brought together for connection to the transmission line at the inner ends. The response obtained with a unit of this type is shown by curve C in Figure 6.

A number of commercial models which have the general appearance of the antenna shown in Figure 7D have been designed to provide broadband reception. A number of these units consist of 4 quarter-wave rods, arranged as shown, and are actually simulated conical antennas. They are often referred to as "Double-V" or "X" type antennas.

Another type useful for broadband reception is the Di Fan antenna in Figure 8 which also has characteristics much like those of the cone antennas.

Long-Wire Antennas

Since the various antennas described in this section are all basically of the half-wave dipole type, their directional patterns are about the same as that of the straight dipole. However, when an antenna length is a wavelength or more, it is known as a LONG-WIRE antenna, and the direction of maximum pickup is no longer broadside to the axis of the antenna. As a general rule, the greater the length of the antenna compared to the wavelength of the signal to be received, the smaller the angle becomes between the direction of maximum pickup and the axis.

For example, a straight or folded dipole which is a half wavelength long on channels 2 to 6 is one and one-half wavelengths long for channels 7 to 13, and therefore, will operate in both high and low VHF bands. However, in the low band its horizontal directional pattern is as shown in Figure 9A, while in the high band, the antenna will function as a long-wire antenna having the characteristics illustrated by Figure 9B. Although there are minor lobes at right angles, the greatest pickup is at angles of approximately 45° to the plane of the antenna.

This change in the directional pattern may either simplify or complicate the orientation of the antenna, depending upon the locations of the respective low and high band VHF stations, and may result in ghost problems due to pickup of reflected signals.

High and Low Band Combinations

In many cases, the desirable all-wave antenna arrangement is one which has the same directional characteristics on both VHF television bands. These characteristics are approached by both the conical and the Di Fan type antennas. Another arrangement, illustrated in Figure 10A, is an antenna called a CONICAL V BEAM which has a directivity pattern similar to that of a dipole on the low band while on the high band its pickup is like a type known as a "V" antenna.

This use of the words "V antenna" should not be confused with that used to describe the physical appearance of other types of antennas, such as the simulated conical antenna of Figure 7D, or the adjustable angle dipoles often employed as indoor antennas.

A V antenna consists of two long wire antennas which are combined to form a V in a horizontal plane so that their main lobes reinforce along the line bisecting the V, and thus result in a very effective directional antenna. That is, if the long wire antenna of Figure 10B is properly combined with that of Figure 10C, the respective directional patterns combine to give the resultant shown in Figure 10D.

In the commercial unit of Figure 10A, the V antenna action has been achieved by bending the rods of the driven element forward. It is a stacked array consisting of two conical V dipoles with reflectors to produce a uni-directional pattern.

Two other commercial types designed for all-channel reception are shown in Figure 11. Figure 11A consists of a long thin dipole mounted close to a short thick dipole, and has a bi-directional directivity characteristic which remains substantially the same for all 12 VHF channels. The Bat-Wing antenna of Figure 11B functions as an ordinary folded dipole for reception of the low band channels, but has a six lobed pattern for the high band with somewhat greater gain on the side on which the short modifying Bat-Wing elements are mounted.

Dual-band VHF antennas consisting of a high band unit and a low band unit mounted on a common mast are shown in Figure 12. Figure 12A is called an In-Line antenna because the high and low band VHF folded dipoles and reflector are all on the same horizontal plane. This antenna is uni-directional on both bands. The long folded dipole and the reflector are used for reception of low band signals, while the long dipole acts as a reflector for the short dipole in the high band. The antenna of Figure 12B provides for individual orientation by using a separate array consisting of folded dipole and reflector for each band.

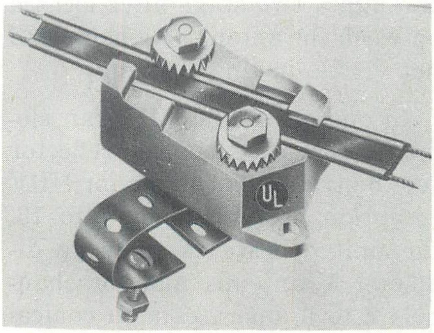
VHF-UHF Combinations

Where both VHF and UHF stations serve an area, the desirable antenna system is one which permits all-channel reception. Four commercially available antennas which have the necessary broadband and directional characteristics are shown in Figures 13 and 14. They are referred to here as the DOUBLE VEE, TROMBONE, ULTRA VEE, and ULTRA FAN.

The double vee antenna consists of two V's in the horizontal plane, and its characteristics are determined to a great extent by the angle between the elements. As shown in Figure 13A, with the elements in position 1, the angle between them is approximately 90° and the antenna gives best results for VHF only. Position 2 provides an angle of about 60° and is optimum for VHF-UHF. Position 3 results in an angle of 45° and is good for UHF only.

The main lobe is in the direction of the open end of the V and thus provides good gain in this direction. A disadvantage of this antenna is that minor lobes exist slightly to each side of the feed point and at the back of the antenna proper. This condition leads to ghosts where reflections are encountered.

Similar to the double vee, the trombone shown in Figure 13B has adjustable elements also. This antenna has lower gain than the double vee in both the VHF and UHF bands. The directivity pattern of the trombone has the main lobe in the direction of tilt, that is, toward the open end of the V. The amplitude of the side and back lobes are lower than the double vee and, therefore, provides greater rejection of ghosts.



A lightning arrester prevents damage to a television receiver by static discharges as lightning striking the antenna.

Courtesy JFD Manufacturing Co., Inc.

Providing good UHF gain with low VHF gain, the ultra vee, shown in Figure 14A, can be used in areas of high or low UHF signal, as well as high VHF signal. On the high channels, the main lobe of the directivity pattern is quite narrow, which makes orientation fairly critical. This is of value in locations where ghosts are a problem. The low channel pattern is quite broad permitting easy orientation.

The ultra fan shown in Figure 14B consists of an all-channel UHF antenna combined with an all-channel VHF antenna. To prevent interaction between the UHF triangular dipole and the VHF fan elements, connections to the transmission line are made through a two stage filter located between the antenna elements and not visible in this drawing.

In operation, the VHF fan elements serve as a sheet reflector for the triangular dipole for UHF reception. For channels 7 to 13, the unit operates as a large diameter V antenna and for channels 2 to 6, operates as a conical or fan antenna with reflector.

The directivity pattern of the ultra fan has the major lobe in the direction of tilt with small secondary lobes at the sides and back. This antenna has good gain over channels 2 through 83 and also provides good rejection of ghosts due to reflections.

Connecting Transmission Line to Two Antennas

When the installation consists of two antennas, as in Figures 12A and 12B, some means must be employed to connect them both to the single input of the receiver. In most cases, when a commercial type antenna is used, the proper transmission line connections are included in the installation instructions. If they are not, or if the antenna system is custom built, then the installer must employ whatever method of connection is most satisfactory from the standpoint of picture quality and practicability.

Whenever possible, it is desirable to connect both antennas to a single lead-in which is then run to the receiver, rather than use two lead-ins. The simplest method available consists of connecting the two antennas with a piece of transmission line of any convenient length, and running the lead-in from the terminals of one of the antennas to the receiver.

When this arrangement gives good reception from all stations that can be received, it is the one to use. However, in many cases, it is found that this system does not result in good picture quality because the two antennas tend to interfere with each other. That is, they both pick up as much signal as possible in both bands and distortion of the picture is produced if both antenna signals reach the receiver input.

The high band VHF antenna may be prevented from loading the low band unit by the method employed with commercial designs of the type illustrated in Figure 12A. In this case, a piece of 300 ohm twin-lead line about 12 to 14 inches long connects the two folded dipoles. The combined line and high band antenna serve as a shorted quarter-wave stub at the low band frequencies.

Since such a shorted quarter-wave stub is equivalent to a parallel resonant circuit, the arrangement results in the high band antenna acting as a high impedance circuit at the point where the stub joints the low band antenna. Therefore, the low band unit is not loaded by the high band antenna when a station on a low band channel is being received.

Often employed with antenna combinations like that of Figure 12B, the isolating arrangement or "harness" of Figure 15A prevents loading the low band antenna by the high band unit, and effectively eliminates the low band unit when a high band signal is being received. In this arrangement, an open-end "stub" is connected to the terminals of the low band antenna. From 12 to 13 inches in length, this stub is a quarter wavelength long at a frequency near the upper end of the high band.

An open-end stub acts like a series resonant circuit and, therefore, short-circuits the terminals of the low band antenna at high band frequencies. This antenna must be connected to the lead-in, but in such a way that the lead-in is not shorted by the open end quarter-wave stub.

This requirement is accomplished by means of a piece of connecting line equal in length to any odd number, N, of quarter-wave sections at the same high frequency to which the shorting stub is tuned. Since its antenna end is effectively shorted at the high frequencies, this connecting line is the equivalent of a shorted quarter-wave stub, insofar as the lead-in is concerned. Therefore, it presents the high impedance of a parallel resonant circuit to the lead-in when a high band station signal is being received.

By means of a connecting line, the high band antenna is prevented from loading the low band unit, as explained for Figure 12A. In Figure 12B, the proper length of this line may be determined experimentally for best results, beginning with a line 14 or 15 inches long. All connecting lines, stubs, and the lead-in are made with 300 ohm twin-lead line.

For extremely stubborn cases, the antennas may be connected with twin-lead transposed once, in each side of which is inserted a filter unit, Z, as shown in Figure 15B. These filters consist of parallel tuned circuits, Figure 15C, made up of five and one-half turns of #18 wire wound on a 5 $\mu\mu$f tubular ceramic capacitor.

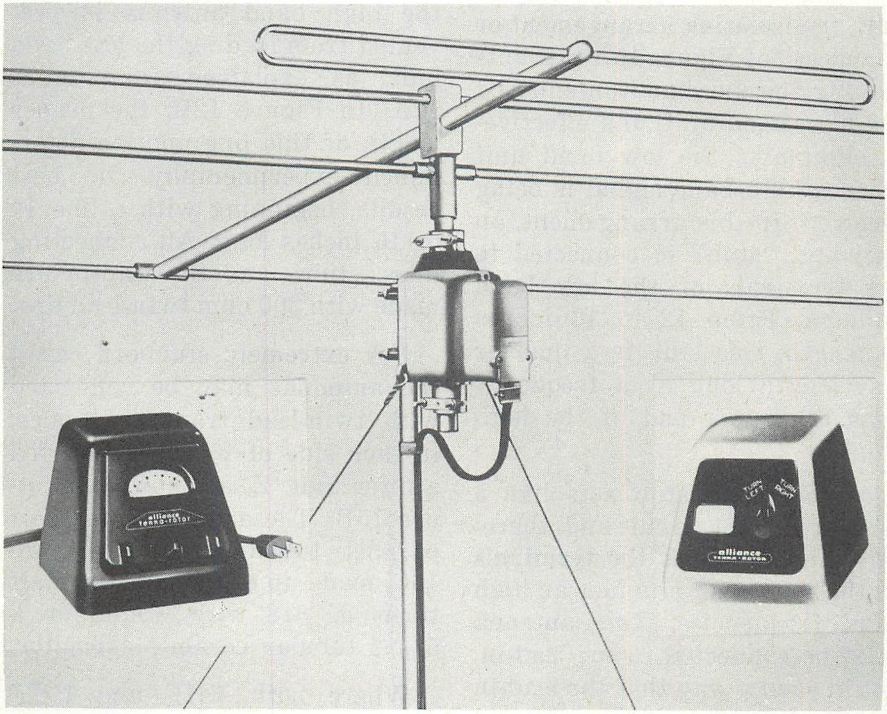
Where both VHF and UHF antennas are mounted on a single mast, a CROSSOVER NETWORK may be used to provide a single lead-in connection to the receiver. As shown in Figure 16A, a short length of transmission line connects each antenna element to the network while a single lead-in connects the antenna system to the receiver. Usually, these connecting lines are 300 ohm twin-lead of the flat, tubular or shielded type.

The schematic diagram of the crossover network is shown in Figure 16B. The network consists of a band-pass filter across each input. By thus presenting low impedance to frequencies outside the pass band, these filters prevent inter-action between antennas.

When none of the above methods are successful, it becomes necessary to run individual lead-ins to an antenna switch at the receiver as explained for Figure 4.

WEAK SIGNAL AREAS

Generally speaking, a "weak-signal area" may be defined as any area in which the signal in-



The rotating antenna can be re-oriented for each station in the area, thus correcting some reception problems. Motor control boxes like those pictured at the left and right are placed on top of or alongside of the receiver cabinet.

Courtesy Alliance Manufacturing Co.

tensity is so low that satisfactory reception cannot be obtained by means of the usual antenna system. With some receivers, a picture of reasonably good quality may be obtained when the input signal level is as low as 50 microvolts. However, a minimum of at least 250 microvolts is usually necessary for a clear picture and freedom from "snow" on the screen. The FCC specifies a signal input level of 500 microvolts as being the minimum required for satisfactory reception. In areas where considerable noise is present, signals of several thousand microvolts intensity may be required to over-ride the noise energy.

In some instances, receiver locations quite close to the transmitter may be characterized by low signal strength due to intervening mountains or buildings. However, for most cases, low signal intensity is due to distance, such as 25 to 150 miles, between the transmitter and receiver locations. The latter type of weak signal areas are known as FRINGE AREAS or as SECONDARY SERVICE AREAS, while the regions within 25 miles of the transmitter are called the PRIMARY SERVICE AREAS. To provide for satisfactory reception in a weak-signal area, some type of special antenna arrangement normally has to be installed, and in extreme cases, a BOOSTER amplifier must be added.

Gain Requirements

Boosters and antennas which are especially designed for weak-signal area reception are generally rated in terms of db gain relative to the signal input derived from a simple straight dipole at a given frequency. In order to determine the approximate gain, and therefore, the type of system that is required for a particular installation, it is necessary to know the sensitivity rating of the receiver and the strength of the signal from the weakest station which it is desired to receive.

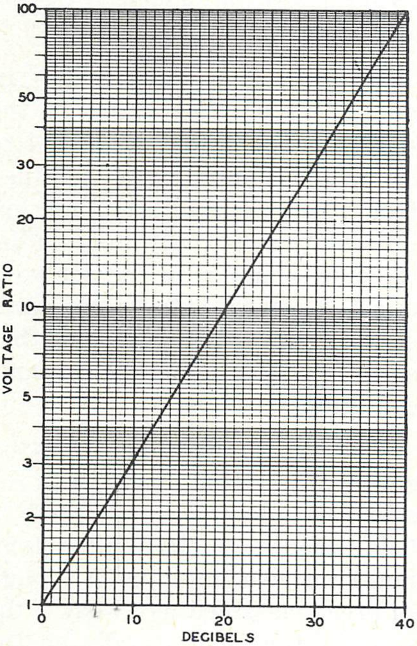
The receiver sensitivity in microvolts may be given in the service manual for the model to be installed, or may be obtained from the manufacturer. An approximate sensitivity may be derived by comparing the set with other receivers of known sensitivity, care being taken that each is checked under the same conditions.

During the pre-installation survey, the signal strength in the area may be measured with a field strength meter and a temporary dipole antenna. Although in areas classified as "weak", the signal strength is usually on the order of 50 microvolts or more, it may be as low as 5 or 10 microvolts in certain locations.

With experience, a serviceman is able to estimate the approximate signal strength with a temporary dipole and a portable receiver if a field strength meter is not available. If desired, a meter calibrated in MICROVOLTS INPUT may be connected to the output of the video detector stage so that the test receiver indicates signal strength as well as the quality of the pictures obtained.

The signal intensity increases with height above ground, and it often is desirable to elevate the test antenna by some means to determine whether the increased pickup so obtained will justify the erection of an antenna tower. One means of doing this is to employ one of the several commercially available, sectional aluminum tubing masts which can be assembled very quickly and temporarily guyed with rope.

CHART 2



As explained in a previous lesson, the decibel, abbreviated "db", is a unit of measure when comparing two like quantities. Chart 2 can be used if it is desired to find the minimum db gain of the selected antenna system when the receiver sensitivity is known and signal strength is known or can be approximated. These voltages are expressed in the following relationship:

$$V_R = \frac{E_r}{E_s} \tag{1}$$

where:

E_r = receiver sensitivity in microvolts.

E_s = signal strength in microvolts.

V_R = antenna voltage ratio.

This can be best demonstrated with an example. Suppose a certain receiver with a sensitivity rating of 100 microvolts is to be installed at a location where the signal strength is 50 microvolts at 30 ft. from the ground. Applying these two values to the equation gives:

$$\text{Voltage Ratio} = \frac{E_r}{E_s} = \frac{100}{50} = 2.$$

Referring to Chart 2, the diagonal line intersects the voltage ratio of 2 horizontal line at the vertical line indicating 6 decibels (6 db). This means that the antenna must have a minimum gain of 6 decibels in the direction of the weakest station.

Antennas for Fringe Area Reception

Various types of high gain antennas are available for use in low signal areas. Each has advantages and disadvantages and, although some types are better theoretically than others for particular applications, a serviceman generally will develop his own special likes and dislikes as he gains experience with the various types.

Besides the technical factors involved, the selection of the antenna system used also may depend upon the customer's desires. Some individuals will insist on minimum cost, in which case the best antenna will probably be one which is just electrically adequate to give a satisfactory picture. Other customers are quite sensitive about the appearance of their antenna installation and being unable to understand that their location may be much better than that of their neighbors so that a less elaborate antenna can be employed, they feel that they are being slighted. For this reason, many servicemen adopt a policy of using only one very good antenna type wherever possible in all weak-signal area installations.

The most numerous of the weak-signal cases are those installations in rural areas near a large city where a number of stations operate on both VHF and UHF channels. Usually, these stations have their transmitters and antennas located atop the taller buildings within a small area in the heart of the city.

The receiver installations must include an antenna system which has sufficiently high gain as well as broad response so that signals from all stations serving the area are supplied with sufficient strength to the receiver. Since all the signals arrive from practically the same direction, the antenna employed may have a uni-directional pickup pattern.

For medium long distance VHF reception, such as 25 to 50 miles, relatively simple dual-band antennas of the type shown in Figure 12 may be used. These units have a gain of approximately 2 to 4 db over that of a straight dipole at the center frequencies of the respective high and low VHF television bands. A gain of 4 to 6 db can be obtained by use of two three-element parasitic arrays, one for each band, mounted one above the other on the plan explained for Figure 4, but oriented in the same direction.

However, this may result in poor reception of some low band stations because of the narrow frequency response of this type of array. Although resulting in a slight loss in gain, the frequency response may be broadened somewhat by tuning or cutting the low band reflector for the lowest channel to be received, the dipole to the center of the band, and the director to the highest low-band channel desired. As the elements of an antenna are essentially tuned circuits, this procedure corresponds to stagger-tuning the i-f coupling circuits in a receiver to increase the over-all bandwidth.

As an example, suppose a particular area is served by stations occupying channels 2, 4 and 5. The limits of this band are 54 mc and 82 mc. The geometrical mean frequency is given by the equation:

$$f_g = \sqrt{f_a \times f_b} \qquad (2)$$

where

f_a = desired band lower frequency

f_b = desired band upper frequency

f_g = geometrical mean frequency.

Substituting 54 mc and 82 mc for f_a and f_b respectively, the geometrical mean frequency is

$$f_g = \sqrt{54 \times 82} = \sqrt{4428} = 66.54 \text{ mc.}$$

The dipole length in inches is given by

$$L = \frac{5549.8}{f_{mc}} \qquad (3)$$

where

L = the dipole length in inches.

f_{mc} = the dipole resonant frequency.

5549.8 = a constant.

To tune it to 66.54 mc, the dipole length is:

$$L_{in} = \frac{5549.8}{66.54} = 83.4$$

or 83½ inches (approx.)

The table of Figure 5 gives lengths of 102 inches for a reflector tuned to channel 2, and 67.3 inches for a director tuned to channel 5.

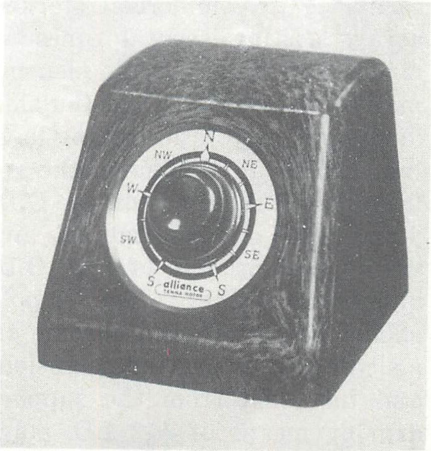
In the case of the high band array, stagger tuning is unnecessary because the ratio of the bandwidth to center frequency is lower and, when cut for channel 10, the three-element array will have fair response over the band. However, if the signal from one station is weaker than those from the others, it may be desired to tune the array to favor the weak station instead of the center frequency of the band.

An alternative method is to employ two antennas like that of Figure 11A, arranged one above the other in a stacked array. This provides reception on all VHF channels and the gain obtained is from 4 to 5 db over that of a dipole. Besides increasing the gain, the stacked array antenna provides better vertical directivity which is advantageous in decreasing the pick-up of noise energy from above and below the antenna.

For greater distances, antenna systems with still higher gain must be used. Giving a gain of from 6 to 7 db, one common unit is the stacked, folded dipole and reflector array shown in Figure 17. Other advantages of this unit are broader response than the three-element array and better vertical directivity. However, this type of antenna does not have a broad enough response to give satisfactory operation over all 12 VHF channels. When stations in both bands are to be received, separate stacked arrays designed for the low and high bands, respectively, should be used. The two arrays may be mounted on the same pole, but should be separated vertically as much as possible.

A high-gain, all-channel antenna which may be used for reception of both VHF and UHF stations is that shown in Figure 14B. Compared to a dipole, this unit has a gain of from 5 db on channel 2, to 5 db on channel 13, and from 4 db on channel 14 to 6 db on channel 83.

For still greater distances, a YAGI array may be used in which all elements are cut and spaced for maximum gain in the channel for which the array is designed. A unit of this type is capable of gains from 8 to 10 db or more, and the one illustrated in Figure 18 consists of folded dipole A, reflector R, and three directors D_1, D_2, and D_3.



An antenna-rotor controller. The dial pointer indicates the direction of antenna orientation.
Courtesy Alliance Manufacturing Co.

For VHF, an antenna of this type is good for reception on one channel only and, therefore, is most useful in areas which are served by a single station. If the signal strength of stations on adjacent channels is high enough, it is possible to secure satisfactory reception from them, although if more than one channel is to be received, it is generally better to employ a separate array for each. The separate arrays should not be coupled to the same transmission line. Instead, separate lines must be run from each and connected to the receiver with a switch as suggested for Figure 4.

Advantages of this antenna, are that it is fairly easy to construct and, in many cases it has proved equal or superior in performance to commercial stacked arrays costing several times as much. The folded dipole element may be made of 3/8″ O.D. (outside diameter) hard brass tubing having .025″ wall thickness, the reflectors and directors of 1/2″ O.D. aluminum or dural tubing, and the supporting arm of 1 1/4″ O.D. aluminum tubing. The dipole should be plated with chrome on a silver base to prevent corrosion, and insulated from the support arm by means of 3/8″ I.D. polystyrene tubing.

Due to the difficulty of bending brass tubing, the dipole ends may be made from short lengths of 5/16″ solid brass rod of the type sold by welding shops for brazing, these being bent into "U" shapes on a 7/8″ radius and inserted two or three inches into the brass tubing. These ends then may be adjusted until the exact desired dipole length is obtained, and then soldered in place.

Mounted in 17/32″ holes drilled through the support arm, the various antenna elements are held in place with set screws. Those set screws which are holding the dipole element must be tightened carefully to avoid cracking the polystyrene tubing.

The vertical mast may be made from a 10′ length of 1 1/4″ thin wall conduit. A standard 300-ohm twin-lead transmission line is connected directly to the folded dipole. If the materials and method of assembly described above are employed, the actual dimensions required may be determined by reference to Figure 5, when all spacing measurements are made from the center of one element to the center of the adjacent element as pictured in Figures 5 and 18.

To permit reception on more than one channel, a less selective antenna is needed, such as a dipole-reflector stacked array similar to that illustrated in Figure 19. This type of unit has a gain of 8 or 9 db or more and, like the antenna of Figure 17, provides reasonably uniform response over either but not both of the VHF television bands. However, the particular model illustrated in Figure 19 actually consists of two separate antennas—one for the low band and one for the high band. Corresponding elements are mounted one-on-another and insulated, and a special matching section is employed to match the antennas to any transmission line between 50 and 60 ohms.

A top view of what is known as a RHOMBIC antenna is shown in Figure 20. This is another long-wire antenna, and each of its "legs" has a length L equal to 2 or more wavelengths at the center-band or design frequency. A gain of about 10 db may be obtained when L is equal to 2 wavelengths, about 13.5 db when L is 4 wavelengths, and about 16 db when L is 6 wavelengths.

The rhombic antenna is unidirectional and rejects reflected signals from the front as well as from the back due to its narrow directivity pattern. Rhombics with legs 2 wavelengths long have a useful horizontal beam width or acceptance angle of approximately 13 degrees, while those with legs 4 wavelengths long have a beam width of 8 degrees.

The greatest disadvantage of this type of unit for VHF is the large space required to accommodate it. However, as well as high gain, the rhombic has a broader frequency response than the arrays of Figure 17 and 19, and providing sufficient space is available, a rhombic antenna may be the best type for certain very weak signal areas.

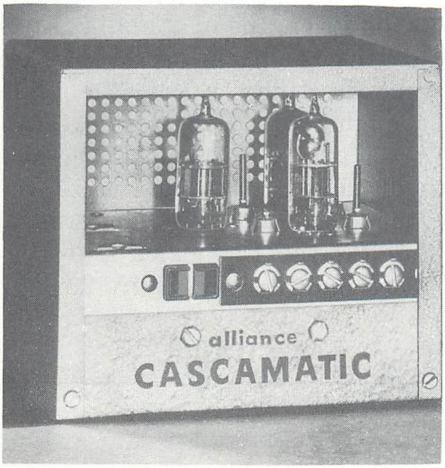
Other advantages of this antenna are that it is relatively easy and inexpensive to construct and the supporting poles on which it is mounted do not have to be more than 30 or 40 feet high. Although broad, its response is not adequate for two-band coverage, and when this is desired, a high-band rhombic can be strung inside the larger low-band unit and thus supported by the same poles. The separation is sufficient to avoid undesirable interaction.

The design data given in Chart 3 for L lengths of 2 and 4 wavelengths results in decreased gain and directivity in order to obtain a slight spread in station directions, or where space restrictions will not permit the use of the longer leg units. The values listed are for the L, S, and D dimensions indicated in Figure 20.

CHART 3

Wavelength of each Leg	**2**	**4**	**6**
Low Band			
L	28′10″	57′ 7″	86′ 5″
S	35′ 6″	53′ 3″	64′ 7″
D	45′ 5″	102′ 2″	160′ 2″
High Band			
L	10′ 2″	20′ 5″	30′ 7″
S	12′ 6″	18′10″	22′11″
D	16′ 1″	22′11″	56′ 8″
UHF Band			
L	3′	6′	9′
S	2′ 7″	3′ 2″	7′10″
D	5′ 5″	10′10″	16′ 1″
Inclination Angle	30°-40°	20°-25°	10°-15°
DB Gain	7	10.5	12.5

The wire employed for the legs of the rhombic antenna may consist of No. 12 hard drawn copper wire. The forward end of the rhombic antenna must be terminated in a non-reactive resistor of approximately 800 ohms. A 300 ohm twin-lead transmission line may be connected directly to the rhombic antenna, the impedance of the antenna being on the order of 700 to 800 ohms. The signal voltage loss due to this mismatch is only about 10 per cent, but may be avoided at some desired frequency by the use of a quarter wave matching section.



A television booster designed to mount on the back of a receiver. This three-stage unit operates on all VHF channels and requires no controls.

Courtesy Alliance Manufacturing Co.

The antenna dimensions are not critical, nor is its exact location critical so long as it is "in the clear". However, due to its sharp directivity, the direction in which the rhombic is pointed must be determined very precisely by experimentation, especially for the long leg units. The forward, or resistor terminated end should be mounted not less than 15 feet above the ground, and the entire unit inclined upward at the angle indicated in Chart 3.

There are many fringe locations where reception of two, three or more stations is possible, but from different directions. Although an antenna system such as described for Figure 4 may be practical when distances are not too great, a system of arrays arranged in this manner for long distance reception would have to be more elaborate and, therefore, rather cumbersome and expensive.

This problem may be solved by means of a motor or other device employed to rotate a stacked or parasitic array until it points toward the station from which reception is desired at any particular moment. The rotating mechanism may be remotely controlled by means of a switch located at the receiver.

Commercial antenna rotators operate from low voltage, such as 24 v a-c, so that a relatively inexpensive 3 or 4 wire rubber covered control cable can be used between the switch and rotator motor. All such units are reversible in direction of rotation so when the 3 position switch is in one position the antenna turns clockwise, and when it is in the opposite position, the antenna turns counterclockwise. In the center switch position, no power is applied and the antenna remains stationary.

Masts and Towers

The height of the antenna is an important consideration in low signal areas. This is due to line-of-sight transmission of VHF and UHF signals. Normally, for VHF reception, the higher the antenna, the stronger the received signal. A slightly different approach must be considered for UHF.

In rural areas, the antenna may be mounted on windmill towers, silos, barns, etc. as explained in a previous lesson. Although the required height is obtained, the location of the antenna may require long lead-ins. In this case, the signal strength at the antenna must be greater than is required at the receiver due to transmission line losses.

When a commercially built tower or mast is used, it can be located near the house to permit short lead-in. As cost is a limiting factor, the height of the tower generally is held to the minimum required for satisfactory reception. Therefore, the location which provides the strongest signal must be selected.

The propagation characteristics of the UHF signal is somewhat different from those of the VHF signal. Two effects occur in the UHF band which require more careful selection of the antenna location: (1) increased reflections, and (2) cancellation of signal.

With antennas designed for UHF only, distant reception is possible over flat terrain or in line of sight locations. In locations where reflections due to hills or buildings are encountered, the reflected signal often is stronger than the direct signal. Thus, the antenna may be oriented to receive the reflected signal.

To prevent ghosts due to reflections, the antennas must have a high front-to-back ratio. This is the ratio of the signal received with the antenna directed toward the station to the signal received with the antenna directed away from the station. The "bow tie" antenna shown in Figure 21 has a front-to-back ratio of 5 to 1 and a forward gain of 5 db.

The "corner reflector" shown in Figure 22 has a gain of 8 db with good rejection of reflections. Providing a gain of 9 db, the yagi shown in Figure 18 often is used in fringe areas.

As explained, increasing the height of the VHF antenna increases the signal. For the UHF antenna, an increase in height may or may not increase the signal, because of cancellation. This is due to two signals arriving from the transmitting antenna by two paths. At various heights from the ground, these signals add or cancel.

This condition is illustrated in Figure 23. When signals A and B are in phase at the receiving antenna, they add to produce an increased output from the antenna. Out of phase signals tend to cancel, thus reducing the antenna output. By moving the antenna up or down and in a horizontal plane as much as three feet may double or even triple the antenna output.

Obstructions in the path of the signal cause much greater attenuation at UHF than at VHF. Trees produce a serious loss in signal, especially when the leaves appear in the spring.

The vibrations of the UHF antenna cause variation in the signal level at the receiver terminals. In some cases, these variations cause the picture to flicker. Therefore, to eliminate the flicker, the antenna and mast must be mounted rigidly.

Transmission Lines

In weak signal areas where high antennas and long transmission lines are required, the line losses become important. It should be remembered that as the frequency increases the transmission line losses increase also. The same problems found in VHF installations also are found in UHF, except that they are more severe.

The 300 ohm, flat twin-lead employed for television is not entirely satisfactory, even for low band VHF under certain conditions. During wet weather, excessive attenuation may result from the film of moisture on the web between the wires.

A tubular type 300 ohm line greatly reduces the losses due to moisture. The losses in coaxial transmission lines remain the same under both wet and dry conditions. However, since coaxial line losses are high, it shouldn't be used except in high noise areas where the shielding definitely improves the signal to noise ratio.

A comparison of the losses of these transmission lines is shown in Chart 4. The losses of each type of line are shown for both wet and dry conditions. Also, notice that these losses are much greater at 700 mc than at 100 mc.

CHART 4

Line Type	Loss in db/100 ft.			
	100 mc		700 mc	
	Dry	Wet	Dry	Wet
300 ohm twin-lead	1.2	7.3	3.6	26.5
300 ohm tubular	1.2	2.5	3.6	8.2
73 ohm coax	3.7	3.7	11.7	11.7
75 ohm coax	1.9	1.9	6.2	6.2

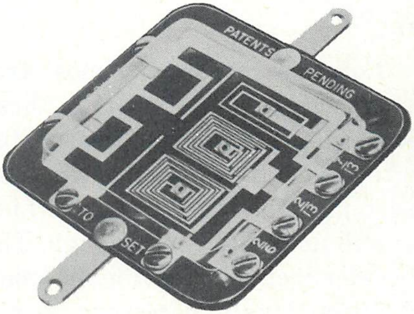
In installation, the transmission line must be kept clear of all objects which absorb energy from the line resulting in attenuation of the signal. For a line carrying UHF signals, the minimum distance should be six inches between the object and line.

Boosters

Where signal losses become excessive due to line length, boosters can be used. These units may be located at the receiver or where noise voltages are induced in the transmission lines. Best results are obtained when the booster is mounted near the antenna.

Also, in weak signal locations where even the most elaborate antenna array is inadequate, or when an elaborate array is impractical or undesirable for some reason, a booster may be used to increase the strength of the television signal. This device is merely a preamplifier consisting of one or more stages of r-f amplification, and tunable over the entire band of television carrier frequencies. There are many types of commercial units available on the market, and it is less expensive to purchase one of these than to at-attempt to build one.

A typical television all-channel VHF booster is connected in the transmission line by terminals provided for the lead-ins from the antenna and to the receiver. A three-position switch permits use of the booster on either the high or low VHF television bands or on neither. That is, in the off position of this switch, the antenna lead-in is connected directly through the booster to the receiver lead-in. A channel-selecting switch similar to that used on the television receiver, permits selecting the proper tuned circuits for the desired station.



The cross-over network is a printed circuit designed to prevent inter-action between VHF and UHF antennas connected to the same transmission line.

Courtesy JFD Manufacturing Co., Inc.

Most boosters contain one or two stages, while three stages are considered the practical limit because of signal-to-noise ratio considerations. Noise energy is developed by thermionic emission in a tube and amplified by following stages.

Furthermore, as well as amplifying the signal, the booster also increases the amplitude of any noise content in the input signal from the antenna system. Thus, although a booster can give some gain and often produces a picture where none was obtained before, its useful gain is somewhat limited by the corresponding increase in the absolute noise level. This noise level would not be increased if the same gain can be realized by means of an improved antenna system.

For this reason, the most frequent use for boosters is in those locations in which all reasonable efforts to improve the antenna system result in a picture which is still not quite good enough. The booster then will provide the small additional gain necessary to obtain satisfactory reception.

While not having as much gain as those using conventional pentode circuits, boosters employing neutralized or grounded grid triodes for amplifiers may result in a better signal-to-noise ratio. The pentode types are usually less expensive and more readily obtainable in a variety of models.

Boosters can be cascaded for greater gain. That is, the output of one booster is connected to the input of the other so that two or more units are in series. The antenna lead-in is connected to the input of the first unit while the output of the last booster is applied to the input of the television receiver.

In some cases however, this arrangement results in a tendency toward instability and oscillation, especially on the higher channels. Any such tendency results in a tremendous increase in noise level. Often, oscillation of cascaded boosters may be prevented by using units of different makes.

ROTATION OF WAVE POLARIZATION

The need for mounting the receiving antenna in the same plane as the electric component of the carrier wave, as well as the fact that certain conditions in the propagation path may result in a change or rotation of the wave polarization, was mentioned in a previous lesson.

To permit compensation for this condition, some commercial antennas are designed to tilt from the horizontal when necessary, and thus provide for maximum signal pick-up. An adjustable angle dipole array of this type is illustrated in Figure 24.

Although this unit is intended for outdoor use, the rotation of wave polarization phenomenon is frequently encountered with indoor antenna installations, and several makes of indoor antennas have been designed to permit similar adjustment. Although an adjustable unit like that shown in the Figure is convenient, it is possible to tilt any type of array, which has the mechanical construction that permits it to be mounted at an angle to the horizontal.

MULTIPLE OUTLET DISTRIBUTION SYSTEMS

One of the greatest television reception problems is that of providing satisfactory signal input to all the receivers in an apartment building, hotel, or any other multiple family dwelling found within the metropolitan areas. Many building owners forbid the erection of separate outdoor antennas for each individual apartment because such a maze of antennas adds an unsightly appearance to the building, decreases property values, and presents the possibility of the owner being financially liable in the event of an accident due to faulty installations.

To overcome this problem, the television industry has developed multiple outlet distribution systems. This method is not original, however. Some years ago many newly erected apartment buildings had broadcast receiving antenna systems built into the walls of each apartment, with a convenient outlet for connecting radios. Also, in more recent years a similar system was adopted for FM reception, with only one master antenna on the roof. The various multiple outlet distribution systems employed for television follow the same basic idea.

A good television multiple outlet distribution system should perform the following functions:

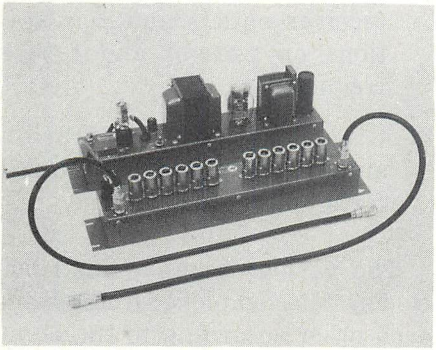
1. Provide sufficient signal strength to the receivers on all channels for clear reception without snow or ghosts.
2. Prevent interaction between receivers.
3. Provide for later addition of receiver outlets and new stations on present and future frequencies.
4. Give satisfactory operation automatically and unattended for a long period of time.

The various types of distribution systems employed differ from each other according to the number of receivers that are to be served. More complex arrangements generally are needed when a large number of receivers are involved.

Master Antenna System

The simplest arrangement is the master antenna system of which there are a few variations. The method generally employed consists of one broad-band antenna on the roof and a cable distribution system to the individual apartments. To prevent upsetting of the line impedance and minimize the effect of receiver interaction, resistance networks and filters are incorporated in the wall outlets for each receiver.

Illustrated schematically in Figure 25 is one arrangement of a resistance network by means of which several receivers may be connected to a single transmission line. In series with the receiver lines, resistors R_2 are used for impedance matching purposes. Connected across the respective lines when the receivers are detached, resistors R_1 are equal to the receiver input impedances.



This broad-band amplifier is useful as a booster in a master antenna system feeding a large number of receivers.

Courtesy The International Telemeter Corp.
Ampli-Vision Division

The substitution of the receiver input by terminating resistors R_1 may be accomplished by means of double pole-double throw switches, illustrated in the Figure, or by plug-in arrangements, etc. This circuit is for use when all receivers have the same input impedance and this impedance is equal to that of the lead-in.

Resistors R_2 may be calculated from the following formula:

$$R_2=\frac{R_1\,(N-1)}{2}. \qquad (4)$$

where R_1 is equal to the impedance of the transmission line and receiver input, and N is the number of receivers to be connected to the line.

To illustrate the use of this Equation, assume that it is desired to connect two 300-ohm input resistance receivers to a single 300 ohm line. Then,

$$R_2=\frac{300\ (2-1)}{2}=\frac{300}{2}=150\ \text{ohms.}$$

With R_2 equal to 150 ohms, the total resistance of the receiver #1 input circuit is 150 + 300 + 150 or 600 ohms. The receiver #2 input circuit has the same resistance. In so far as the transmission line is concerned, it is terminated by a resistance of 600/2 or 300 ohms and so will deliver maximum energy to the load. Of course, resistors R_2 in series with the receiver inputs cause power losses so that not all of the energy reaching the end of the transmission line is delivered to the receivers. This loss must be accepted when isolating receivers by means of resistor networks.

A typical master system is shown in the diagram of Figure 26. Though appearing somewhat complex, this arrangement follows a rule of impedances which states that when two identical impedances are connected in parallel, the resultant impedance is equal to half of that of one. A pair of 300 ohm branch lines are connected in parallel to match each of the two 150 ohm riser lines, which in turn are paralleled to match the 75 ohm main line connecting to the antenna.

All of the individual outlet boxes are the same and contain a resistance network like that shown at the lower part of the Figure. It is not necessary that various branch lines contain the same number of outlet boxes, and the number connected to each may vary from 1 up to a maximum determined by the antenna signal strength.

In each box resistor R_1 is equal to 300 ohms, and is connected into the circuit when the television receiver is not. In any one branch circuit, all the resistors R_2 are equal, their resistance being determined by the number of outlets to be incorporated in that branch. The resistors R_2 may be calculated from equation (4). In the case of the four outlets illustrated in Figure 26, R_2 is 450 ohms. Thus, the total resistance of the two resistors R_2 plus the input impedance of the receiver is equal to $450 + 450 + 300$ or 1200 ohms. Connected in parallel across the branch line, the four 1200 ohm outlet boxes have a total equivalent impedance of 1200/4 or 300 ohms, which matches the line.

Since the signal present in the antenna and lead-in system is in the form of electric power, and each outlet box resistance and receiver input circuit is a power consuming device, there is a limit to the number of outlets that can be served by such a system, depending upon the strength of the received signal.

In some cases, it may be desirable to connect two receivers in different parts of a house or another building to one antenna through individual transmission lines. Isolation of one receiver from the other may be achieved by means of resistor networks at the receiver or antenna end of the transmission lines as pictured in Figure 25, or it can be achieved by the arrangement of Figure 27.

Inductors L_1 and L_2 are bifilar coiled transmission lines an inch or two long that are enclosed in a housing attached to the mast close to the antenna. Due to the distributed inductance and capacitance of the coils, the transmission line sections function as LC filters that provide a selected degree of attenuation for all signal in the frequency range from the lowest VHF television channel to the highest UHF television channel. Thus, the signal amplitude at the receiver terminals is slightly less than that at the antenna terminals. However, the signal loss in the coiled transmission line coupler is not as great as that in the resistor network for the same degree of receiver isolation.

Receiver isolation is due to the fact that the transmission line sections are in series between the receiver terminals. Any spurious radiation from one receiver must pass through both sections of the filter and thus be attenuated twice as much as the desired signal before it reaches the other receiver.

Two more bifilar coiled transmission lines may be connected to the antenna terminals to provide isolation for a total of four receivers.

Pre-Amplifiers

In cases where a master antenna distribution system does not provide enough signal power for satisfactory operation of a large number of receivers, an arrangement employing pre-amplifiers will give better results.

Perhaps the simplest method is the use of a commercial booster in the main feed line to amplify the signal directly from the antenna. This requires a booster having extremely wide bandwidth if signals received on a number of different channels in both the VHF and UHF bands are to be amplified.

Since such a booster cannot provide very much amplification, it is more practical to use separate boosters for each channel, with their inputs and outputs common to the main feed line. However, a single booster is useful where only one station is to be received.

Where many receivers are to be served, another, more elaborate system uses separate high gain amplifiers with separate antennas for each channel. Usually, such an installation is manufactured and installed by companies specializing in this type of work. Like boosters, the characteristics to be considered with these multiple system amplifiers are gain, band-width, and signal-to-noise ratio.

The better types use low-noise circuits and have gains up to about 48 db with a bandwidth of 6 megacycles. If the simpler master antenna type system is already installed but not giving satisfactory results, amplifier units and additional antennas usually can be added, and the existing antennas and cable distribution with outlet boxes retained.

Receiver Isolation

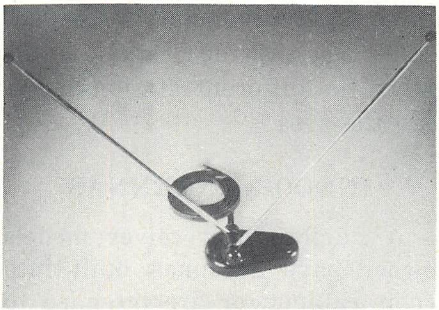
With multiple outlet distribution systems, the main trouble encountered is the receiver interaction caused by the various local oscillators radiating energy into the common lead-ins. One method of overcoming this trouble is the use of special isolating transformers designed for the purpose. Called DISTRIBUTION TRANSFORMERS, the units employed in one commercial system provide isolation of approximately 100,000 to 1, or 50 db.

Another way of overcoming receiver interaction is the use of a separate cathode follower circuit between the lead-in and each receiver. The cathode follower serves as an isolating device, and also affords a method of matching the line impedance to that of the receiver input. When the signal strength is sufficient, cathode followers can be used with the master antenna system without pre-amplifiers, but most often are used with the systems containing amplifiers.

Complex Systems

Figure 28 shows a complex distribution system employing separate antennas and pre-amplifiers and containing distribution transformers (D.T.) for isolation and impedance matching purposes. Systems of this type employ a separate antenna and pre-amplifier for every channel being used in the area, and the illustration shown is for reception on channels 4, 5, 7, and 9.

Even though a single broad band antenna could be used, separate units can be tuned and oriented for best results with each station. Also as shown, the system includes antennas and amplifier units for FM and AM broadcast and short-wave reception. The cost of these additional components is small compared to that of the complete installation.



The adjustable indoor antenna often is used in strong signal areas where an outdoor type cannot be mounted on the building. Generally, it provides better reception than a built in antenna.

Courtesy The Radiart Corp.

The diagram of Figure 28 shows the outputs of the various amplifiers connected to a common line which is connected to the input of the first distribution transformer. From this unit, four outputs are connected to the input circuits of four more distribution transformers, each of which has four outputs connected to the inputs of four additional distribution transformers, although the connections of only one branch line are shown in the drawing.

That is, if all the units were included in the Figure, the lower line would contain a total of 16 distribution transformers.

Finally, the outputs of each of these lower distribution transformers connect to four receiver outlets, so that a total of 4 × 16 or 64 receivers can be served by this system. The input of each channel booster amplifier contains a potentiometer to compensate for varying signal levels from the different stations serving the area.

INDOOR ANTENNAS

A number of receiver models either have antennas built into their cabinet, or are intended to operate with some other type of indoor antenna. As mentioned above, many apartment house owners, etc. do not permit the installation of outdoor antennas, in which case the television receiver owner's only recourse is an indoor antenna or possibly some type designed to be mounted on a window sill.

It is quite common to make a folded dipole antenna from a length of 300 ohm twin lead transmission line. Although the antenna usually is attached inside the receiver cabinet, it often can be concealed behind a picture on the wall, back of a curtain or cornice, or under a rug.

To fill the need for indoor antennas, a number of commercial types have been placed on the market. A common type consists of two rods mounted in the form of a V, on a ball-type base. The unit is self-supporting and usually may be stood on the top of the receiver cabinet or any convenient table, etc. The telescoping dipole rods can be adjusted in length for tuning to the desired channel, and the entire assembly is rotated by hand for maximum signal pickup.

Another type, known as a SLIDE RULE FOLDED DIPOLE, has a physical appearance much like that of the steel measuring tape used by carpenters. That is, the element consists of metal ribbons which slide horizontally in and out of the mounting base. The unit is extremely compact and its retracting feature provides easy portability. Being a folded dipole, the antenna matches a 300 ohm transmission line, and settings are marked on the ribbon loops for each of the 12 VHF television channels as well as for FM reception.

Still another arrangement employs the 117 volt power line as the antenna, and has a capacitor to couple one side of the line to the receiver antenna post. It provides low impedance to the r-f signal it couples from the power line to the receiver input. A choke coil located in the power line lead between the power supply transformer primary and the point where the coupling capacitor is connected prevents the transformer from short-circuiting the r-f signals.

Because of the relatively small energy which an indoor antenna can pick up, it generally is employed only in the immediate vicinity of the transmitter where the signal strength is very high. However, it is possible to employ an indoor antenna in an area of somewhat lower signal strength if a booster amplifier is used. Also, the practicability of the latter arrangement will depend upon the noise present at the particular location. One manufacturer has designed a combination unit consisting of a booster and an adjustable "V" antenna similar to that described above.

Proper dimensions and impedance matching must be considered when using any indoor type antenna if the best performance is to be obtained. In addition, the antenna must be oriented for best reception. Many times, it is found that the best signals do not necessarily come from the directions of the transmitter. Reflections from nearby walls may cause a strong signal to be intercepted at an unexpected angle.

ATTIC ANTENNAS

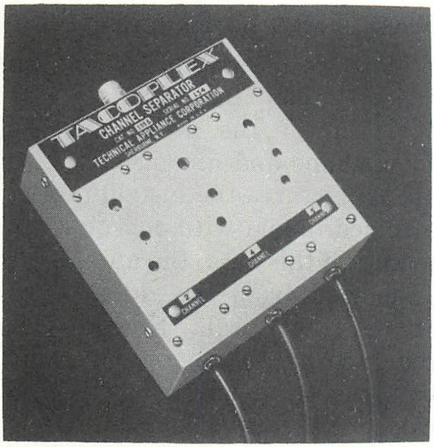
Almost any outdoor antenna will function as an attic antenna, provided there is adequate space. However, the efficiency of an attic antenna installation depends upon such factors as the amount and location of electric wiring conduit, or ventilating system ducts, and the type of roof. Proximity to any large metal masses should be avoided, since they may shield the antenna or may reflect out of phase energy to the antenna.

Methods of antenna mounting depend upon the interior construction of the attic, and the room shape and dimensions. Figure 29 pictures the installation of a folded dipole with reflector antenna. In this case, the antenna is suspended from the ridge board at the roof peak. However, if room permits, the antenna may be turned over and mounted on a wood block attached to the attic floor.

LIGHTNING ARRESTOR

An ungrounded television antenna, particularly if it is large and well elevated, is a lightning hazard. When grounded, it provides a measure of protection. Therefore, the mast should be grounded and the transmission line provided with a lightning arrestor of the type suitable for the transmission line employed.

Figure 30 pictures the internal construction of one type of lightning arrestor that is used with a parallel-pair or twin-lead transmission line. One transmission line conductor connects to lug A, the other connects to lug B, and the GND lug is attached to a good earth ground, preferably a cold water pipe. Carbon blocks separate lugs A and B from the ground plate and provide a high-resistance path to ground for minor static charges. If the antenna is struck by lightning, the resulting heavy charge is carried to ground by a spark that jumps from the inner ends of lugs A and B to the ground plate.



When a separate booster for each channel is employed in a master antenna system, a channel separator may be used between the antenna and the boosters.

Courtesy Technical Appliance Corp.

The recommended method of lightning arrestor installation is pictured in Figure 31. The antenna mast is grounded by means of a heavy copper wire run up the side of the house from a water pipe or other good earth ground to the antenna mast. The transmission line is run down the side of the house to the point of entry, where the lightning arrestor is attached.

If the antenna is struck by lightning, a major portion of the discharge current is carried to ground through the ground wire, and only a small amount passes down the transmission line. With the arrestor positioned as shown, the major portion of the transmission line discharge passes through it, and is kept from entering the receiver.

COLOR TELEVISION RECEPTION

The considerations for antennas, transmission lines and boosters are basically the same for color television reception as they are for monochrome reception. When a good black-and-white picture, free of reflections (ghosts) and noise is obtained, it is more than likely that a good color picture will be obtained.

Most of the standard broadband antennas will give satisfactory reception of color pictures. For example, the antennas of Figures 13 and 14 have sufficient bandwidth and directivity to provide adequate frequency coverage with a minimum of ghosts. When the serviceman chooses an antenna for color TV reception, bandwidth and directivity are probably more important than gain. If the antenna does not have sufficient bandwidth to pass the 3.58 mc burst signal and the chrominance information, the color portion of the reproduced picture will suffer. Also, reflections are much more troublesome during a color reception than during a monochrome reproduction. Besides appearing as various lines and shades in the picture, a reflected signal can cause partial or complete cancellation of the burst and result in weak or no colors. The directivity of the antenna is also important in reducing interference which appears as various colors.

Should considerable difficulty be encountered with reflections, probably the most practical solution would be to choose an antenna that has a narrow beam-width (not bandwidth), and use it in conjunction with an antenna rotator.

Impedance matching between the transmission line and the antenna is not critical. In fact a Voltage Standing Wave Ratio (VSWR) of more than 5 to 1 has been tried experimentally and found to have very little effect upon the reproduced color picture. The impedance match between the transmission line and the receiver input terminals is considerably more critical and a mismatch that produces a VSWR of more than 3 to 1 can cause cancellation of the burst signal in the same manner as reflections.

If the location of the color receiver is in a weak signal area that requires the use of a booster for good black-and-white reception, the bandwidth of the booster should be sufficient to prevent attenuation of the burst and the chrominance information.

In the next lesson, many time saving devices that enable the technician to do a better and faster job of servicing are explained.

* * *

PRACTICE PROBLEMS

1. The measured strength of a television signal in a rural area is 75 microvolts at a height of 50 feet. What is the minimum voltage gain required of an antenna if the receiver sensitivity is 300 microvolts?

2. What is the required decibel gain of the above antenna?

3. A certain area is served by television stations on channels 7 and 9. What is the geometrical mean frequency of this band if the lower frequency is 174 mc and the upper frequency is 192 mc?

4. To what length must an antenna for the above mean frequency be cut?

5. Three 300 ohm input resistance television receivers are connected to one 300 ohm transmission line. What value isolation resistors should be used?

ESSENTIAL SYMBOLS AND EQUATIONS

E_r = receiver sensitivity (microvolts)

E_s = signal strength (microvolts)

f_{mc} = antenna resonant frequency (mc)

f_a = desired band lower frequency (mc)

f_b = desired band upper frequency (mc)

f_g = geometrical mean frequency (mc)

L = Antenna length (inches)

N = Number of receivers

R_1 = Receiver input resistance (ohms)

R_2 = Isolation resistance (ohms)

V_R = Antenna voltage ratio

$$V_R = \frac{E_r}{E_s} \tag{1}$$

$$f_g = \sqrt{f_a \times f_b} \tag{2}$$

$$L = \frac{5549.8}{f_{mc}} \tag{3}$$

$$R_2 = \frac{R_1\,(N-1)}{2} \tag{4}$$

STUDENT NOTES

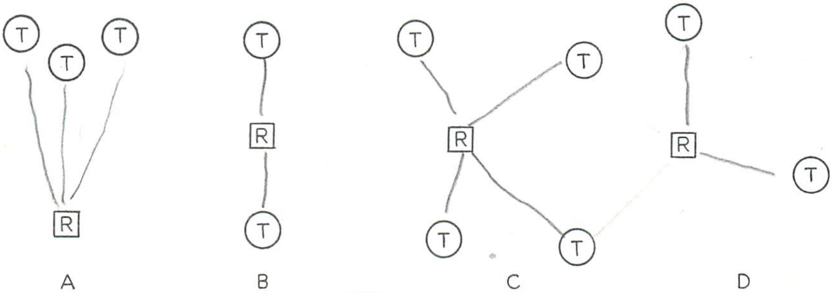


FIGURE 1

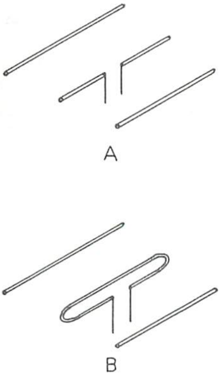


FIGURE 2

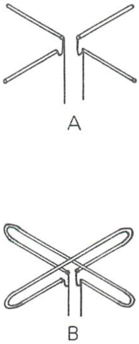
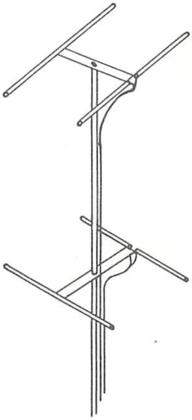


FIGURE 3



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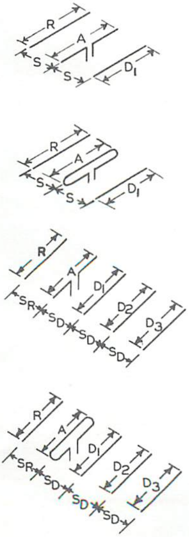


Channel No.	Element Length in Inches				Element Spacing in Inches		
	A	R	D_1	D_2 & D_3	S	S_R	S_D
2	97.2	102	93.3	92.5	50.5	31.0	21.25
3	88.0	92.3	84.4	83.75	45.7	28.0	18.75
4	80.0	84.3	77.0	76.5	41.7	25.75	17.25
5	70.0	73.6	67.3	66.75	36.4	22.25	15.0
6	65.2	68.2	62.5	62.0	33.9	20.75	13.75
7	31.2	32.8	30.0	29.75	16.2	10.0	6.75
8	30.2	31.8	29.0	28.75	15.7	9.75	6.5
9	29.2	30.8	28.1	28.0	15.2	9.5	6.25
10	28.4	29.8	27.2	27.0	14.7	9.0	6.0
11	27.6	29.0	26.4	26.0	14.3	8.75	5.75
12	26.8	28.2	25.7	25.5	13.9	8.5	5.625
13	26	27.3	24.9	24.75	13.5	8.25	5.5

FIGURE 5

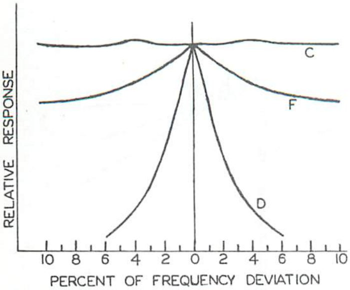
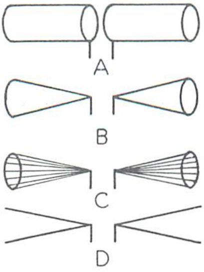


FIGURE 6



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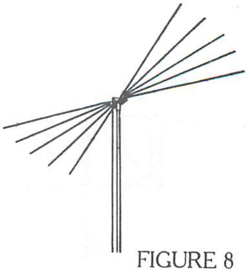

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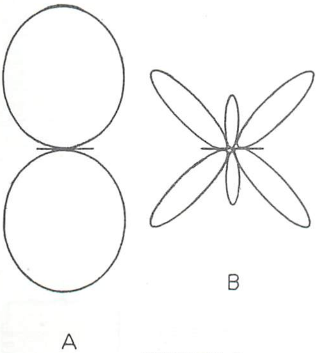

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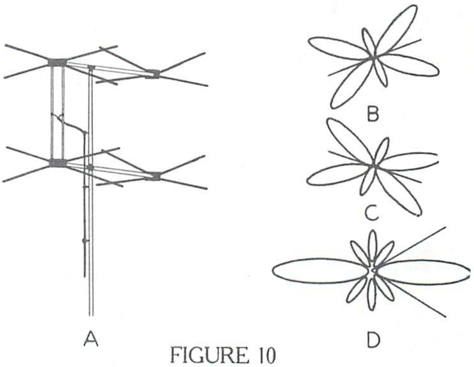

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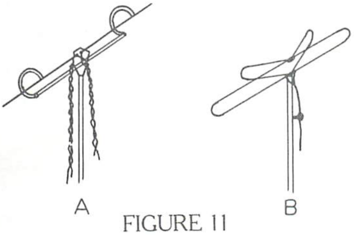
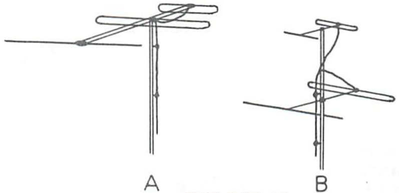


FIGURE 11



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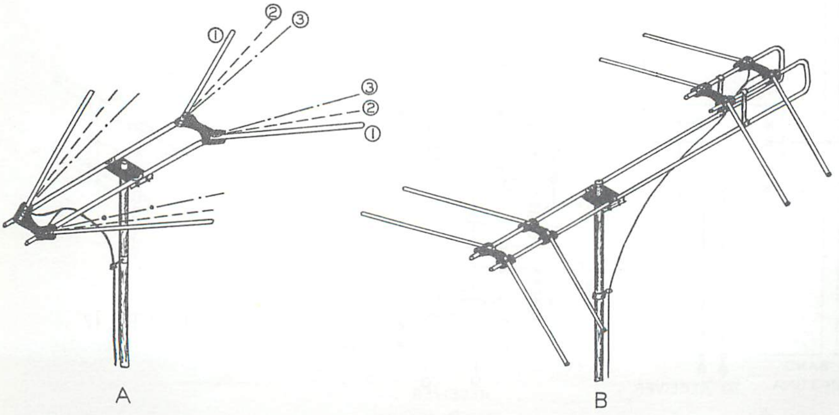


FIGURE 13

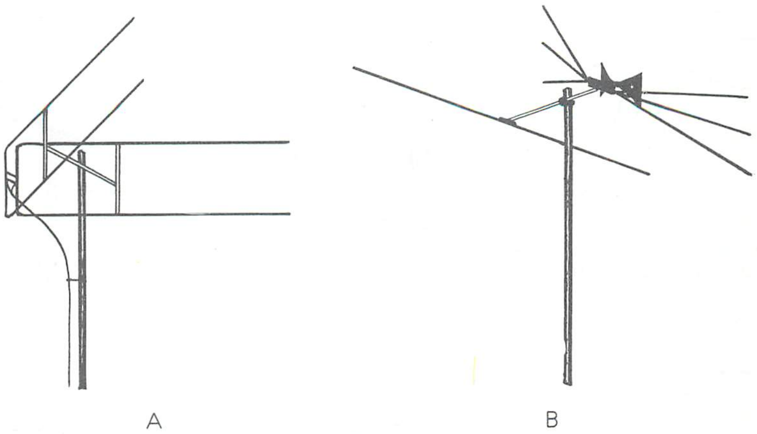
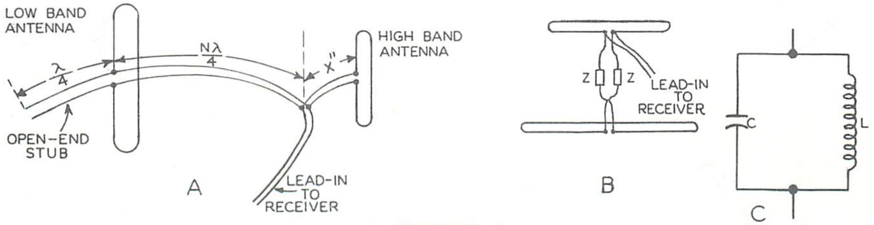


FIGURE 14



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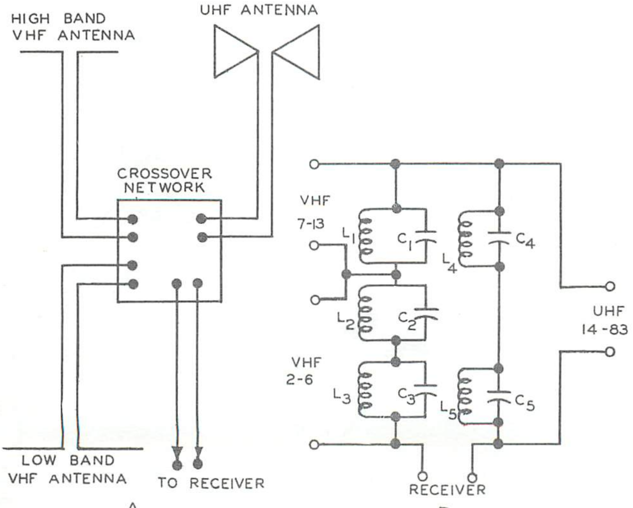

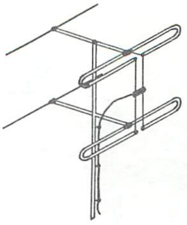

FIGURE 17

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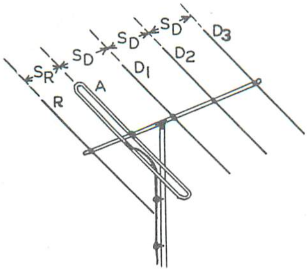
FIGURE 16



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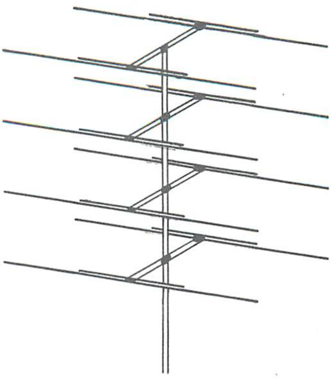


FIGURE 19

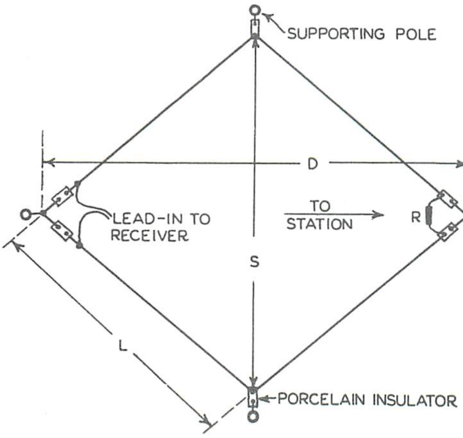
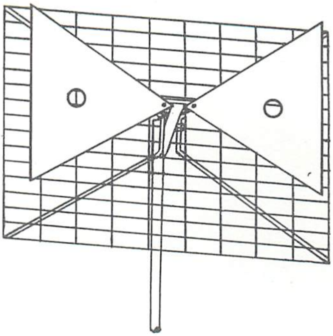


FIGURE 20



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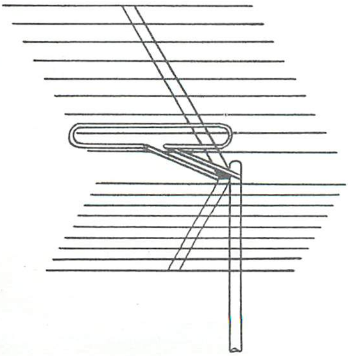

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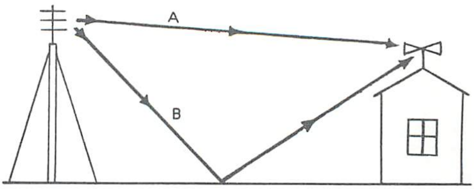

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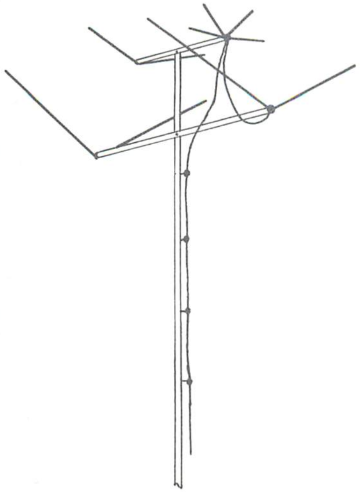

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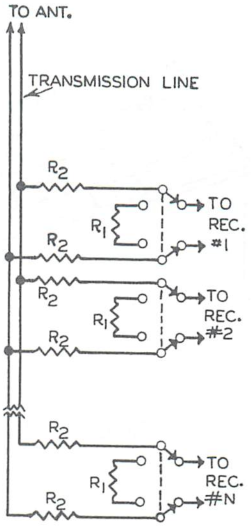

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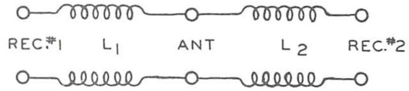

FIGURE 27

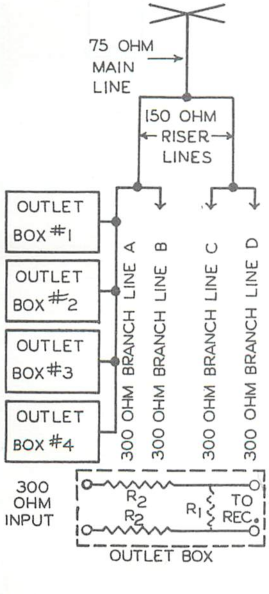

FIGURE 26

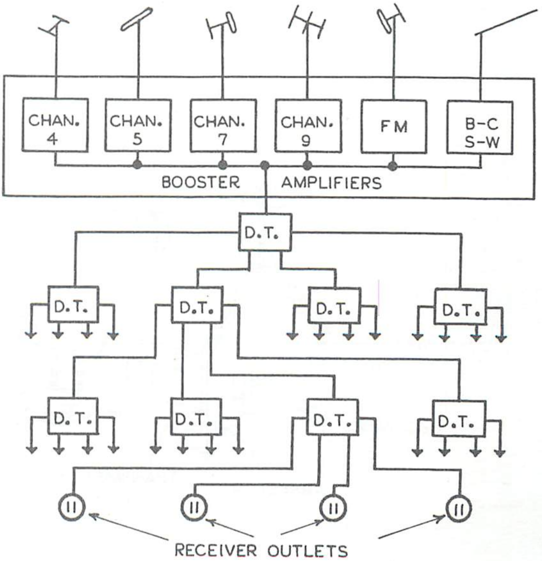

FIGURE 28

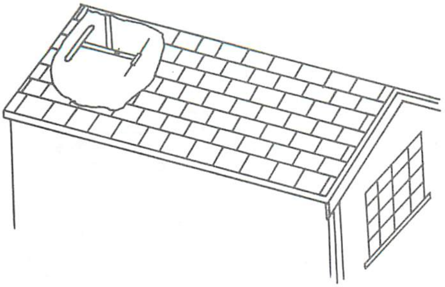

FIGURE 29

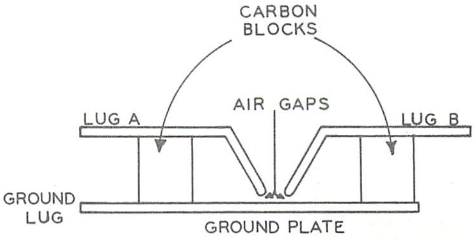

FIGURE 30

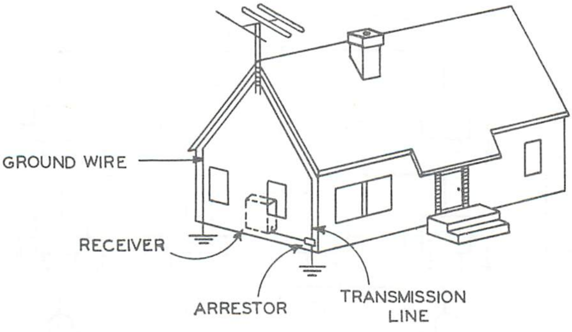

FIGURE 31

PRACTICE PROBLEM SOLUTIONS

1. From equation (1):

$$V_R = \frac{300}{75} = 4$$

2. Referring to Chart 2, page 16:

Decibels $= 12$

3. From equation (2):

$$f_g = \sqrt{f_a \times f_b} = \sqrt{174 \times 192} = \sqrt{33408} = 182.8 \text{ mc}$$

4. Substituting the above frequency into equation (3) gives

$$L = \frac{5549.8}{f_{mc}} = \frac{5549.8}{182.8} = 30.3 \text{ inches}$$

5. From equation (4):

$$R_2 = \frac{R_1\,(N-1)}{2} = \frac{300\,(3-1)}{2} = \frac{600}{2} = 300 \text{ ohms.}$$

FROM OUR *Director's* NOTEBOOK

"CLOTHE YOUR WORDS WITH A SMILE"

"But I only told him the truth!" How often we've heard that defensive statement—and what a world of blundering it tries to cover. Friendships have gone flying out the window, business opportunities down the drain — washed away by thoughtless, impulsive words.

By all means, be truthful . . . always. But temper the blunt truth with a few nice words. Getting along with your fellow man is extremely important when you're in business. Personality and winning ways have a great deal to do with success.

Wear a smile often . . . talk with the "soft pedal" on . . . clothe your very words with your smile. It pays off. Softly spoken, sincere words bring far greater returns to ANYONE than hastily spoken harsh words.

Yours for success,

W. C. De Vry

DIRECTOR

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